	Hits	Search Text	DBs	Time Stamp
1	6	(("5605857") or ("5985731") or ("6395650")).PN.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:36
2	6	("4505949" | "5669979" | "5709754" | "5814156" | "5980983" | "6117706").PN.	US-PGPUB; USPAT; USOCR	2004/12/10 10:47
3	11	("6117706").URPN.	USPAT	2004/12/10 10:47
4	10	("4638400" | "5065220" | "5109357" | "5119154" | "5185689" | "5196909" | "5300799" | "5381302" | "5479316" | "5576240").PN.	US-PGPUB; USPAT; USOCR	2004/12/10 10:47
5	12	("5985731").URPN.	USPAT	2004/12/10 10:48
6	4	("5030587" | "5227322" | "5459105" | "5488007").PN.	US-PGPUB; USPAT; USOCR	2004/12/10 10:48
7	78	("5605857").URPN.	USPAT	2004/12/10 10:48
8	600723	capacitor	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:50

	Hits	Search Text	DBs	Time Stamp
9	169	low adj temperature adj dielectric	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:50
10	138950	(aluminum adj oxide) or AlO or (aluminum adj nitride) or AlN	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:51
11	12	S8 and S9 and S11	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:52
12	49	S8 and S9	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:52
13	3066	(low adj temperature) near4 dielectric	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:52

	Hits	Search Text	DBs	Time Stamp
14	138950	(aluminum adj nitride) or AlN or (aluminum adj oxide) or AlO	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:53
15	356	S14 and S15	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:53
16	793	expos$6 near4 (Al or Aluminum) near8 (oxygen or nitrogen or N or O)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:54
17	574	S17 and temperature	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:54
18	421	S18 and ((@ad<"20010105") or (@rlad<"20010105"))	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:55

	Hits	Search Text	DBs	Time Stamp
19	150	S19 and (low near2 temperature)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:55
20	25	S20 and S8	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 10:55

	Type	L #	Hits	Search Text	DBs	Time Stamp
1	IS&R	L7	879	(438/239).CCLS.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 13:35
2	IS&R	L11	2241	(438/253).CCLS.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 13:59
3	IS&R	L13	4217	(438/396).CCLS.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 14:07
4	IS&R	L14	1188	(438/240).CCLS.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	2004/12/10 14:32

US-PAT-NO: 6376355

DOCUMENT-IDENTIFIER: US 6376355 B1
See image for Certificate of Correction

TITLE: Method for forming metal interconnection in semiconductor device

---------- KWIC ---------

Application Filing Date - AD (1):
19980819

Brief Summary Text - BSTX (5):
In general, a semiconductor device includes transistors, resistors and capacitors. A metal interconnection is required for realizing the semiconductor device on a semiconductor substrate. The metal interconnection which transmits electric signals must have low electric resistance, and be economical and reliable. Aluminum has been widely used as a metal interconnection.

Brief Summary Text - BSTX (10):
Subsequently, a barrier metal layer, i.e. a titanium nitride (TiN) layer, is formed on the entire surface of the resultant structure where the interdielectric layer pattern is formed. Here, when the recessed region is the contact hole for exposing the predetermined region of the semiconductor substrate, i.e. a source/drain region of a transistor, an ohmic metal layer must be formed on the entire surface of the resultant structure where the interdielectric layer pattern is formed, before forming the barrier metal layer. Then, the barrier metal layer is annealed at a predetermined temperature if necessary, to fill the grain boundary region of the barrier metal layer with oxygen atoms. This is for preventing the diffusion of silicon atoms of the semiconductor substrate through the barrier metal layer.

Brief Summary Text - BSTX (14):
The metal layer may be formed through sputtering, a chemical vapor deposition (CVD) or a plating process. Preferably, the CVD process

is
performed at a temperature range corresponding to a mass transported region
instead of a surface reaction limited region and at a pressure of 5 Torr or
higher so that the metal layer is not formed in the recessed region. It is
preferable that an argon gas and a hydrogen gas are used for a carrier gas and
a reducing gas, respectively. The hydrogen gas may be used as a carrier gas.
Also, the sputtering process for forming the metal layer is performed such that
atoms sputtered from the target lose directionality to prevent the
anti-nucleation layer from being formed in the recessed region. That is, it is
preferable that the sputtering process for forming the anti-nucleation layer is
performed at several mTorr using a DC magnetron sputtering apparatus without a
collimator to utilize the poor step-coverage.

Brief Summary Text - BSTX (16):

As described above, the anti-nucleation layer for exposing the barrier metal
layer formed in the recessed region has characteristics of the insulating
layer, so that a metal layer, i.e. an aluminum layer or a copper layer, may be
selectively formed in the recessed region. This is because the time required
for forming metal nuclei on the anti-nucleation layer being an insulating layer
is several tens through several hundreds times longer than the time required
for forming metal nuclei on the barrier metal layer being a metal layer.
Subsequently, a metal plug for filling a region surrounded by the exposed
barrier metal layer, e.g. an aluminum plug, is formed through a selective MOCVD
process. The metal plug may be formed of Cu or W instead of Al. Preferably,
the aluminum plug is formed through a selective MOCVD process using a precursor
containing Al. It is also preferable that the selective MOCVD process for
forming the aluminum plug is performed at a temperature corresponding to a
surface reaction limited region of aluminum, e.g. at a temperature

lower than
300.degree. C. It is preferable that the precursor containing the aluminum is
one selected from the group consisting of tri-methyl aluminum, tri-ethyl
aluminum, tri-iso butyl aluminum, di-methyl aluminum hydride, di-methyl ethyl
amine alane, and tri-tertiary butyl aluminum. Also, the selective MOCVD
process uses an argon carrier gas and a hydrogen reducing gas.

Brief Summary Text - BSTX (19):

According to another (second) embodiment of the present invention for accomplishing the above object, an interdielectric layer pattern having a recessed region, a barrier metal layer pattern and an anti-nucleation layer are formed in the same manner as the first embodiment, to thereby expose the barrier metal layer formed on the sidewalls and bottom of the recessed region. Also, like the first embodiment, an ohmic metal layer may be formed on the entire surface of the resultant structure where the interdielectric layer pattern is formed, before forming the barrier metal layer, and the barrier metal layer may be annealed after forming the barrier metal layer. Then, the metal liner is selectively formed on a surface of the exposed barrier metal layer. Here, the metal liner may be a single metal liner or a double metal liner obtained by sequentially forming first and second metal liners. It is preferable that the single metal liner is a metal layer formed of one selected from the group consisting of Cu, Al, Ag, Au, W, Mo and Ta. Also, the single metal liner may be a metal alloy layer containing one selected from the group consisting of Al, Au, Ag, W, Mo and Ta, and at least one selected from the group consisting of Cu, Si, Ge, Ti and Mg. It is preferable that the first and second metal liners of the double metal liner are a copper liner and an aluminum liner, respectively. The copper liner is formed through a selective

MOCVD process using a precursor containing Cu, e.g. Cu+1(hfac)TMVS, as a metal source and the aluminum liner is formed through a selective MOCVD using a precursor containing Al as a metal source. Here, the copper liner and the aluminum liner are formed at **temperature** ranges corresponding to surface reaction limited regions of Cu and Al, respectively. Preferably, the precursor containing Al is one selected from the group consisting of tri-methyl aluminum, tri-ethyl aluminum, tri-iso butyl aluminum, di-methyl aluminum hydride, di-methyl ethyl amine alane, and tri-tertiary butyl aluminum.

Detailed Description Text - DETX (7):

Subsequently, the barrier metal layer 109 is treated at a predetermined **temperature** to fill a grain boundary region of the barrier metal layer with oxygen atoms, which is known as a stuffing process. Metal atoms of the ohmic metal layer 107 react with silicon atoms of the impurity layer 103 to form a metal silicide layer. When the barrier metal layer 109 is annealed, then the contact resistance is improved due to a metal silicide layer formed between the impurity layer 103 and the barrier metal layer 109. A diffusion phenomenon of silicon atoms in the impurity layer 103 and aluminum atoms diffusing in the metal layer to be formed in a subsequent process may be suppressed by the stuffed barrier metal layer 109. Accordingly, in the case of forming only the damascene interconnection, the process of forming the ohmic metal layer 107 and a process of annealing the barrier metal layer 109 can be omitted. The process of annealing the barrier metal layer 109 is performed at 400.about.550.degree. C. in a N.sub.2 atmosphere for 30-60 minutes, or at 650.about.850.degree. C. in a NH.sub.3 atmosphere through rapid thermal processing (RTP). The RTP is preferably performed for 30-120 seconds.

Detailed Description Text - DETX (10):

When the material layer 111 is formed using the DC magnetron sputtering apparatus having no collimator at 3.about.10 mTorr, or more preferably 5.about.10 mTorr, the directionality of the sputtered metal atoms is lost to thereby prevent formation of the material layer 111 in the recessed region. Accordingly, as shown in FIG. 2, the material layer 111, is selectively formed only on the interdielectric layer pattern 105, leaving the copper layer 110 formed in the recessed region exposed. The semiconductor substrate is cooled to a temperature corresponding to that of a surface reaction limited region, i.e. 10.about.30.degree. C. (in the aluminum layer) or preferably, 25.degree. C. to thereby form an aluminum layer.

Detailed Description Text - DETX (11):

When the metal layer is formed at a low temperature, the metal layer having a uniform thickness may be obtained even when an ultra thin film of 20 A or less is formed. Alternatively, the material layer 111 may be formed through a chemical vapor deposition process. It is preferable that the material layer 111 is formed of a metal layer having excellent oxidation characteristics, e.g. an aluminum (Al) layer, a titanium (Ti) layer, or a tantalum (Ta) layer. It is preferable to use a chemical vapor deposition process for forming the material layer 111 at a temperature corresponding to that of a mass transported region instead of the surface reaction limited region and a pressure of 5 Torr or higher, to prevent formation of the material layer 111 in the recessed region.

Detailed Description Text - DETX (12):

For example, in the case that the material layer 111 is formed of the aluminum layer through the chemical vapor deposition process, when the aluminum layer is formed at a temperature range corresponding to that of the mass transported region of aluminum, i.e. approximately 180.degree. C. or

higher,
the aluminum layer may be prevented from being formed in the recessed region.
It is preferable that argon and hydrogen are used for a carrier gas and a
reducing gas, respectively.

Detailed Description Text - DETX (22):
FIG. 3 is a sectional view for illustrating a step of forming a metal plug
117. In detail, the metal plug 117 for filling a region surrounded with the
metal liner 115, i.e. an aluminum plug, is formed through a selective MOCVD
process. The selective MOCVD process for forming the aluminum plug is
performed using a dimethyl-ethyl-amine-alane (DMEAA) as the metal source, at a
deposition temperature of 100.about.200.degree. C., preferably 120.degree.
C., and 0.5.about.5 Torr, preferably 1 Torr. A bubbler is used for supplying
the DMEAA, the metal source, into a process chamber of the MOCVD apparatus
which is maintained at room temperature.

Detailed Description Text - DETX (27):
When the metal plug 117 is formed of other metal layers instead of the
aluminum layer, then the metal plug is preferably reflowed at a temperature of
0.6.times.Tm or higher. Here, Tm denotes the melting temperature of the metal
layer for forming metal plug 117. A native oxide layer must not exist on the
surface of the metal plug 117 in order to perform the reflow process.

Detailed Description Text - DETX (36):
Meanwhile, the process temperature for selectively forming the copper liner
is determined according to the material of the lower layer, i.e. exposed film
material in the recessed region. For example, when the copper liner is
selectively formed on a surface of a titanium nitride layer, it is preferable
that the deposition temperature of the copper liner is
0.about.350.degree. C.
Preferably, the copper liner is formed at a pressure of 10 Torr and the

temperature of the metal source, i.e. Cu.sup.+1 (hfac)TMVS, is maintained at 40.about.50.degree. C.

Detailed Description Text - DETX (37):

FIG. 8 is a sectional view illustrating a step of forming a metal layer 219. In detail, the metal layer 219, i.e. an aluminum layer or an aluminum alloy layer, is formed on the entire surface of the resultant structure where the metal liner 218 is formed through a combination of CVD and sputtering processes. It is preferred that the aluminum layer or the aluminum alloy layer is formed at a temperature below the reflow temperature. This is to prevent formation voids in the metal layer during planarizing of the metal layer 219 through a reflow process.

Detailed Description Text - DETX (38):

FIG. 9 is a sectional view illustrating a step of forming a planarized metal alloy layer 219a. In detail, the resultant structure where the metal layer 219 is formed is annealed at a predetermined temperature to reflow the metal layer 219. It is preferable that the annealing temperature of the metal layer 219, formed of an aluminum layer or an aluminum alloy layer is 350.about.500.degree. C. When the metal layer 219 is reflowed by annealing, the metal liner 218 and the metal layer 219 are mixed to form the metal alloy layer 219a having a planarized surface. The planarized metal alloy layer 219a may be formed through a process of additionally forming the metal layer 219 at 350.about.500.degree. C. instead of the reflow process.

Claims Text - CLTX (27):

20. The method of claim 19, wherein the selective MOCVD process is performed at a temperature corresponding to a surface reaction limited region of aluminum using a precursor containing aluminum.

Claims Text - CLTX (59):

46. The method of claim 75, wherein the selective MOCVD process is

performed at a temperature corresponding to a surface limited region
of copper
using a precursor containing Cu.

Claims Text - CLTX (62):
49. The method of claim 48, wherein the selective MOCVD process
is
performed at a temperature corresponding to a surface limited region
of
aluminum using a precursor containing Al.

Claims Text - CLTX (88):
61. The method of claim 59, wherein the aluminum layer is
nitrided by
exposure to a nitrogen plasma.

Claims Text - CLTX (99):
65. The method of claim 63, wherein the aluminum layer is
nitrided by
exposure to a nitrogen plasma.